PATENT ABSTRACTS OF JAPAN

(11)Publication number : **09-253975**
(43)Date of publication of application : **30.09.1997**

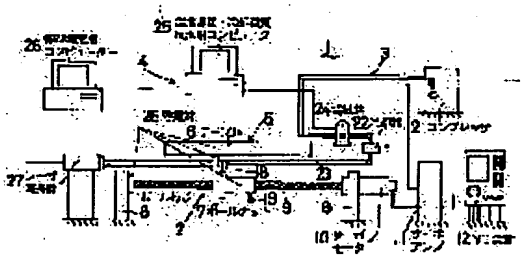
(51)Int.CI. **B23Q 11/14**
B23Q 11/12

(21)Application number : **08-067543**
(22)Date of filing : **25.03.1996**

(71)Applicant : **NAKAZAWA HIROSHI**
MITSUI SEIKI KOGYO CO LTD
(72)Inventor : **NAKAZAWA HIROSHI**
ORITA KAZUHIDE

(54) DEVICE FOR REDUCING THERMAL DEFORMATION OF THREADED SHAFT AND METHOD FOR REDUCING THERMAL DEFORMATION OF THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To restrict heat generated by friction between a threaded shaft and a nut member threadably engaged with the shaft to a specified value under a control of a supplying amount of compressed cooling air and its timing, reduce a thermal displacement at the threaded shaft and improve a position setting precision.



SOLUTION: A ball nut 7 thredably engaged with a ball screw 9 is enclosed by a nut cover member formed with an air flowing-in passage. Compressed cooling air flowed from a compressor 21 is supplied to an air flowing-in passage of the nut cover member so as to cool a contacted location between the ball nut 7 and the ball screw 9 contacted with the ball nut 7. In turn, a difference in temperature between the nut cover member and a table 6 or the like is deleted by a thermocouple 26 or the like, and an ON/OFF control of the compressed cooling air is carried out in reference to whether or not the difference exceeds a reference value. With such an arrangement as above, a heat generated at the ball nut and the ball screw 9 is reduced and a position setting precision is improved.

LEGAL STATUS

[Date of request for examination] 07.03.2003
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of

...is Page Blank (...pto)

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is used for various machine tools etc., and relates to the heat deformation reduction equipment and the approach of a simple **** shaft of reducing deformation by the heat expansion of a feed screw shaft which performs migration positioning of the migration section of a machine.
[0002]
[Description of the Prior Art] A feed screw shaft like a ball thread is used for the part which has the need of carrying out migration positioning of the mobile with high precision in a predetermined location, like a machine tool. It is required to prevent this heat deformation to raise positioning accuracy with this feed screw shaft. As this means, various kinds of heat deformation reduction means are adopted from before. For example, what avoids excessive precompression, the thing which selects the big ball thread of a lead and lowers a rotational frequency, What expects beforehand the amount of heat expansion by the temperature rise, and only the part makes subtract [specified quantity] an accumulation criteria lead error, and is manufactured, The thing which was made short beforehand a little and which applies tension beforehand so that it may **** and bigger internal stress than thermal stress may be produced on a shaft, What is used after performing the thing and warming up which carry out selection use of the suitable lubricant and stabilizing temperature, What a screw-thread shaft circulates a cooling medium in Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. in midair as for, the thing which pours and ****s air and a lubricating oil to the peripheral face of a **** shaft, and cools a shaft, Various means, such as what passes air and an oil mist and is cooled from the hole established in the spacer of a double nut precompression ball thread, and a thing which performs the amount complement control of heat expansion by the closing troop control system, are devised, and it is applied concretely.
[0003]
[Problem(s) to be Solved by the Invention] Although the exoergic reduction means of the above mentioned conventional screw-thread shaft has effectiveness, respectively, the screw-thread shaft of a special configuration is required, or it is complicated also about the control means, and there is a trouble by cost rise. Moreover, it has the trouble which is hard to apply easily and cheaply. on the other hand, it becomes the cause of heat deformation of a **** shaft -- the Lord -- it is most which a heat source is ****ed with the nut-like member in a ball thread, and is depended on the frictional heat at the time of the drive between a shaft and a ball in the meantime, if the heat of this part can be compulsorily reduced with an easy means, it will ****, and heat deformation of a shaft can be reduced sharply. At works, a compressor is established permanently and, generally the condensator which makes predetermined temperature cool the compressed air is also established permanently in many cases. In addition, special establishment is required to use a vortex tube etc. Then, it became clear in the phase of preliminary experiment that said trouble is solved by cooling directly the nut-like member which ****s using this compression cooling air and is in contact with the shaft. That is, between the members engaged mutually, many heat flows to a low temperature side by carrying out a heat sink. Therefore, if a nut-like member is cooled, a nut-like member will ****, it will become low temperature from a shaft, and heat will flow to a nut-like member side. Stripping of the heat conducted to the nut-like member is carried out outside. It turned out that conduction of the heat by

the side of the **** shaft currently screwed in it by performing the temperature control of a nut-like member decreases by the above, and the temperature control is performed.
[0004] Generally the calorific value Q produced to the contact part of a screw-thread shaft and the nut-like member screwed in this is calculated by the following formula.
Q**n-T ... (1)
Here, n is the rotational frequency of a **** shaft and T is torque value by which a load is carried out to a screwing part. Moreover, temperature rise deltatheta of the **** shaft which can be set in this case is called for by the following formula.
delta theta=Q/beta [1-exp (1-t-beta/CM)] ... (2)
Here, beta is [heat capacity and t of heat release and CM] elapsed time. If elapsed time t is enlarged here, it will become delta theta=Q/beta and will be saturated. On the other hand, when the die length of a **** shaft is set to L and an thermal expansion coefficient is set to alpha, it ****s, and amount of heat expansion deltaL of a shaft becomes like the following formula.
delta L=alpha-delta theta-L ... (3)
Drawing 7 ****s with the time amount t based on (aforementioned 1) thru/or aforementioned (3) types, relation with the elongation of a shaft is shown, and change of the conventional screw-thread shaft is shown by Curve A.
[0005] Calorific value Q can be compulsorily reduced from the above thing, and the value of deltaL can be sharply made small by removing the heat for Qj from Q, considering as Q'=Q-Qj, and considering as delta L=alpha-Q ' / beta-L.
[0006] It is originated in view of the above situation, and this invention supplies the standing compression cooling air by the compressor and the condensator to a nut-like member, cools a nut-like member compulsorily, and aims at the thing which **** by the simple means and the simple approach of carrying out on-off control of supply of compression cooling air so that the temperature may be held in a predetermined reference value, and reduced heat deformation of a shaft sharply and for which it ****s and the heat deformation reduction equipment and the approach of a shaft offer.
[0007]
[Means for Solving the Problem] This invention is heat deformation reduction equipment for reducing generation of heat at the time of a drive with the **** shaft by which is held at the immobilization side of the nut-like member held at a machine's migration side, and said machine, screws in said nut-like member, and a rotation drive is carried out, in order to attain the above purpose. A nut-like member cooling means to make homogeneity carry out contact engagement of the compression cooling air from a compressor and a condensator on the external surface of said nut-like member, and to cool this nut-like member, While detecting the temperature gradient by the side of said nut-like member and said machine, the heat deformation reduction equipment of the **** shaft which comes to prepare the control section which carries out on-off control of the supply of the compression cooling air of said nut-like member cooling means based on this detection value is constituted. Furthermore, the nut covering member to which said nut-like member cooling means wraps the periphery of said nut-like member entirely concretely, The airstream ON way which is formed in the contact part of this nut covering member and said nut member, and is formed in homogeneity along with the periphery of this nut-like member, The control valve which consists of the compressor and condensator which make compression cooling air frequent this airstream ON way and by which said control section is interposed between said airstream ON ways and said compressors, It is characterized by the heat deformation reduction equipment of the **** shaft which consists of the control section which performs on-off control of said control valve based on a difference with the temperature by the side of the machine with which this etc. is connected with the temperature of said nut-like member and/or said nut covering member. Moreover, it is the heat deformation reduction approach for reducing generation of heat at the time of the drive of a **** shaft by which is held at the immobilization side of the nut-like member held at a machine's migration side, and said machine, screws in said nut-like member, and a rotation drive is carried out. The temperature gradient said screw-thread shaft, the engagement part of a nut-like member, and by the side of the machine with which this etc. is held is detected, on-off control of the compression cooling air supplied to said engagement part based on this detection value is carried out, and it is characterized by the heat deformation reduction approach of a **** shaft of holding said temperature

gradient within a reference value.
[0008] Compression cooling air is supplied to homogeneity with a nut-like member cooling means to engage with a nut-like member at the periphery of a nut-like member, and a nut-like member is cooled to homogeneity. The temperature of a nut-like member is measured at the time of the drive of a machine, and on-off control of the supply of compression cooling air is carried out so that the temperature may be held at a predetermined reference value. It can perform certainly reducing generation of heat generated by the above in the circumference of the screwing section of the **** shaft screwed in a nut-like member and it by very simple means and approach.
[0009]
[Embodiment of the Invention] Hereafter, the gestalt of operation of the heat deformation reduction equipment of the **** shaft concerning this invention and an approach is explained in full detail with reference to a drawing. First, drawing 1 explains the configuration of the gestalt of operation of the heat deformation reduction equipment of this invention. Heat deformation reduction equipment 1 consists of control-section 4 grade which divides roughly and controls the nut-like member cooling means 2, the compression cooling air feed zone 3, and the amount of supply of compression cooling air.
[0010] First, drawing 1 explains the delivery device section 5 of the machine with which heat deformation reduction equipment 1 is applied. As shown in drawing 2 , the ball nut 7 is fixed to the table 6 carrying the workpiece of **** etc. On the other hand, the both ends of a ball thread 9 are supported pivotably between the susceptor 8 by the side of the immobilization of a machine, and 8, and a servo motor 10 is connected with the end side of a ball thread 9. A servo motor 10 is connected with NC unit 12 through a servo amplifier 11. NC unit 12 controls the rotational frequency of a servo motor 10. According to the above structure, a ball thread 9 rotates by rotating a servo motor 10, and the ball nut 7 and table 6 which are screwed in this are moved along with the axis of a ball thread 9. In addition, migration positioning of a table 6 is performed by the revolving speed control of the servo motor 10 by NC unit 12. If a ball thread 9 carries out heat deformation according to the above structure as described above, even if the engine speed of a servo motor 10 is the same, the migration die length of the ball nut 7 and a table 6 changes, and the trouble which cannot perform positioning to a right location arises.
[0011] Next, an example of the nut-like member cooling means 2 is explained. As shown in drawing 2 , while the ball nut 7 which is an example of said nut-like member in this example consists of flange 7a and shank 7b, and it ****s to the inner circumference side, screwing in the ball thread 9 which is an example of a shaft and **** is formed, two or more long slots 13 by which the division-into-equal-parts rate was carried out to the circumferencial direction are cut in the periphery of shank 7b along the direction of an axis. On the other hand, the nut covering member 14 is a barrel which wraps shank 7b entirely to the Lord of the ball nut 7, consists of flange 14a and tube-like object 14b which fits into shank 7b, and attaches covering 15.
[0012] Drawing 3 and drawing 4 show the condition of having inserted the nut covering member 14 in the ball nut 7. The nut covering member 14 is inserted in the ball nut 7 until the flange 14a contacts flange 7a of the ball nut 7, and the tube-like object 14b wraps shank 7b of the ball nut 7 entirely. In addition, as shown in drawing 2 , O rings 16 and 17 are inserted in the ball nut 7 side, and the seal by the side of the both ends of the ball nut 7 and the nut covering member 14 is performed. Moreover, the seal of the both ends of the long slot 13 of the ball nut 7 is carried out by fixing covering 15 to the nut covering member 14 side.
[0013] As shown in drawing 3 thru/or drawing 5 , the air inlet section 18 and the air appearance regio oralis 19 which are open for free passage inside are prepared in the end side of flange 14a of the nut covering member 14, and shank tube-like object 14b. The airstream ON way 20 which makes the air inlet section 18 and the air appearance regio oralis 19 open for free passage is formed its long slot 13 and both-ends side by inserting the nut covering member 14 in the ball nut 7. When air is introduced into the air inlet section 18, as it is shown in drawing 5 , air progresses in the direction of an arrow head, and it passes along the long slot 13, and is discharged from the air appearance regio oralis 19 by the above structure.
[0014] Next, the compression cooling air feed zone 3 is explained. As shown in drawing 1 , the compression cooling air feed zone 3 consists of an introductory path 23 for introducing into the air

inlet section 18 of the nut covering member 14 the cooling air from a compressor 21, the condensator 22 which cools the compressed air to desired temperature, and a compressor 21 and a condensator 22, and solenoid-valve 24 grade which is an example of the control valve interposed into the introductory path 23. In addition, a compressor 21, a condensator 22, and a solenoid valve 24 are connected with an NC unit 12 side, and are controlled.

[0015] By this example, a control section 4 consists of a thermometry and a computer 25 for cooling air control, and thermocouple 26 grade that is an example of a thermometric element, and is connected with NC unit 12. In addition, the laser length measuring machine 27 and the computer 28 for elongation measurement are attached, and the computer 28 for elongation measurement is connected the thermometry and computer 25 side for cooling air control. Moreover, in this example, a thermocouple 26 is connected with the susceptor 8 which supports the nut covering member 14, the air inlet section 18, a table 6, and a ball thread 9, and performs temperature detection in parts, such as it. This detection value is inputted into a thermometry and the computer 25 for cooling air control. On the other hand, the laser length measuring machine 27 engages with the nut covering member 14, location measurement of the nut covering member 14 is performed, and the measured value is inputted into the computer 28 for elongation measurement. In addition, the laser length measuring machine 27 is sometimes unnecessary, and a thermometry and the computer for cooling air control can actually be changed into small IC device.

[0016] Next, an operation of the heat deformation reduction equipment 1 of this invention is explained. If a servo motor 10 is driven, a ball thread 9 is rotated and the ball nut 7 moves along with a ball thread 9, frictional force will arise between a ball thread 9 and the ball nut 7, and the contact part will generate heat. The temperature of the ball nut 7 rises by the generation of heat. While a thermocouple 26 detects the degree of the temperature rise of the ball nut 7 through the nut covering member 14, a thermocouple 26 performs the thermometry of the comparatively low part of the temperature change of table 6 grade. On the other hand, the amount of location gaps of the nut covering member 14 grade by the temperature rise of the circumference of the ball nut 7 is measured by the laser length measuring machine 27, and is inputted into the computer 28 for elongation measurement. On the other hand, the compressed air from a compressor 21 is sent to the air inlet section 18 of the nut covering member 14 through a condensator 22, and is introduced into the airstream ON way 20. This compression cooling air flows the inside of the long slot 13 formed in the periphery of shank 7b of the ball nut 7 at homogeneity, and absorbs the heating value generated to the contact part of the ball nut 7 and a ball thread 9 during that circulation. In addition, since the long slot 13 is formed in the periphery of shank 7b comparatively [division-into-equal-parts], the ball nut 7 and a ball thread 9 are cooled by homogeneity. From the air appearance regio oralis 19, ** ON of the compression cooling air which absorbed the frictional heat of the ball nut 7 and a ball thread 9 is carried out, and recycling is carried out to a compressor 21 side. While controlling the amount of supply of the compression cooling air from a compressor 21, the temperature of the nut covering member 14 is controllable to desired temperature by controlling the supply time amount and timing. For this reason, the heating value conducted to a ball thread is reduced sharply, and heat deformation of a ball thread is suppressed by min. Moreover, change of the amount of location gaps after control is measured by the laser length measuring machine 27.

[0017] Next, drawing 6 thru/or drawing 8 explain an example of the heat deformation reduction approach of the ball-thread 9 grade in the heat deformation reduction equipment 1 of this invention. Drawing 6 shows the elongation time amount diagram at the time of taking the elongation [mum] of a ball thread 9 along an axis of ordinate, taking elapsed time [min] along an axis of abscissa, driving a ball thread 9 for 1 hour, and carrying out by repeating the pattern of operation which performs a drive halt after that for 30 minutes. In drawing, Curve C shows the case where compression cooling air is not supplied to a ball-thread 9 side, D curve shows the case where compression cooling air is controlled and supplied based on the heat deformation reduction approach of this invention, and E curve shows the case where compression cooling air is always supplied without control, respectively. According to the heat deformation reduction approach of this invention, it becomes possible to hold down elongation in the very small range so that clearly [in a diagram].

[0018] Drawing 8 is a flow chart which shows the example of the heat deformation reduction approach of this invention. First, machine starting is performed (step 100). A compressor 21 is

turned on with a machine drive, a solenoid valve 24 opens, and compression cooling air is supplied. That is, air ON (step 101) is performed. Next, when a machine does not stop, it progresses to step 103 (when it is no), and the temperature (specifically temperature of the nut covering member 14) of the temperature (for example, temperature of a table 6) of a machine and a ball thread 9 is measured. On the other hand, when the machine has stopped, actuation of a compressor 21 is suspended (when it is yes), a solenoid valve 24 closes, and it becomes Air OFF (step 104). Next, the temperature comparison by the side of a machine and a ball thread 9 is made, the temperature gradient is searched for, and it is judged for the temperature gradient whether it is less than a reference value (step 105). In order to prevent supercooling, in within (in the case of yes) a reference value, it progresses to step 104, and it suspends supply of air, it judges that cooling is insufficient in beyond (in the case of no) a reference value, and continues Air ON (step 106). By repeating the above control and performing it, the temperature rise of a ball thread 9 is controlled within constant value.
[0019]
[Effect of the Invention] According to this invention, the following remarkable effectiveness is done so.
1) Axial temperature was able to be maintained at the original temperature, and heat expansion was able to be suppressed and controlled by absorbing generation of heat when assuming roughing by the ball thread with forced cooling below to about 10 [mum] (setting to the measurement axial length 500 [mm]) (since the coefficient of linear expansion of structural carbon steel was 1.2x10-6 [mm/degree C], controlling **** within 2 [**] was shown). In addition, also in roughing, still highly precise **** control is attained by enlarging capacity of a condensator.
2) The direction of refrigeration capacity has exceeded to generation of heat when assuming finish-machining, and it was able to stop within **2 [mum] by performing ON-OFF control.
3) Since the temperature of a nut covering member front face was measured and turned on and off, control was easy and the elongation of a shaft was able to be suppressed somewhat uniformly by setting up small the temperature width of face of turning on and off.
4) This invention is [which uses the nut-like cooling means of a standing compressor or simple structure] only easy, and can be carried out cheaply and easily.
5) Since direct calorific value is taken, performing forced cooling does not leave heat compared with other approaches.
6) It is applicable also to an established machine.

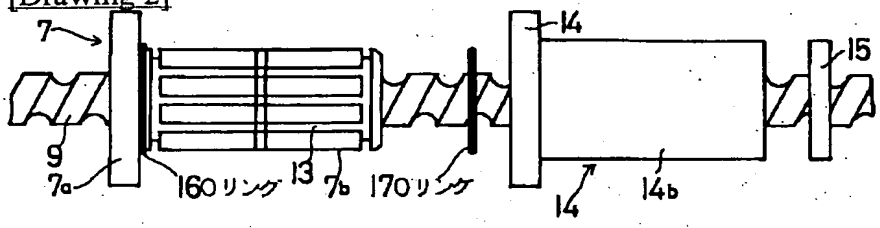
[Translation done.]

* NOTICES *

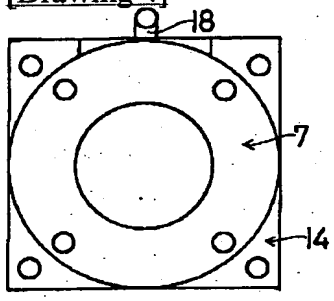
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

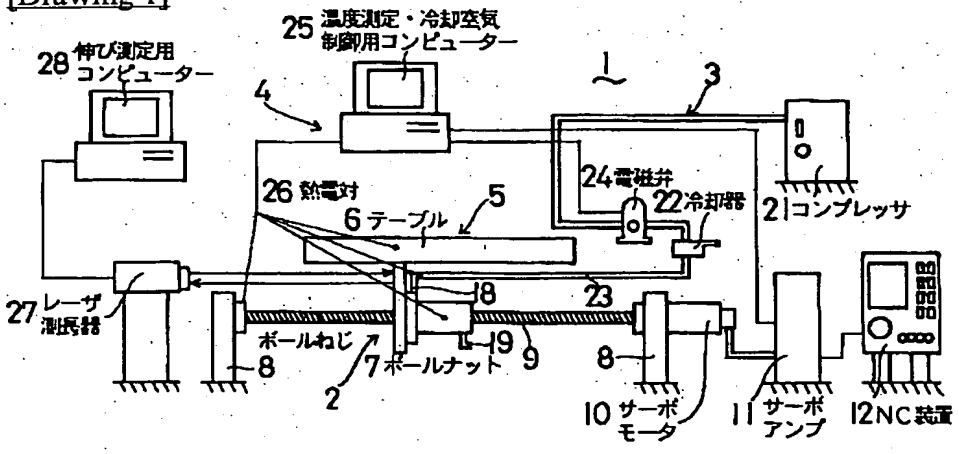
[Drawing 2]



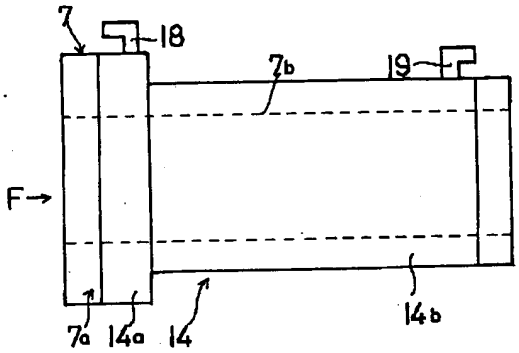
[Drawing 4]



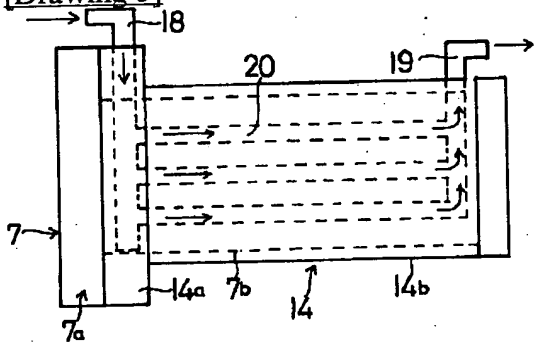
[Drawing 1]



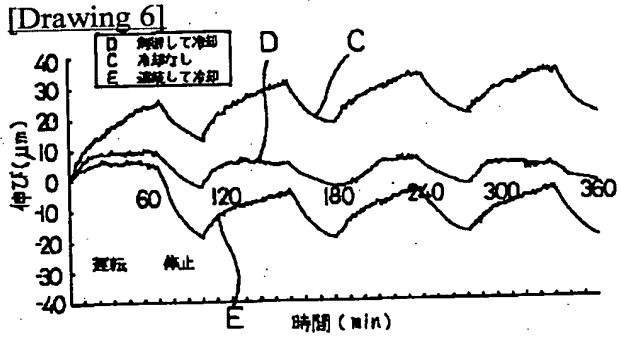
[Drawing 3]



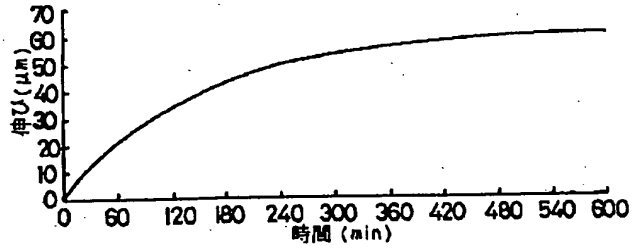
[Drawing 5]



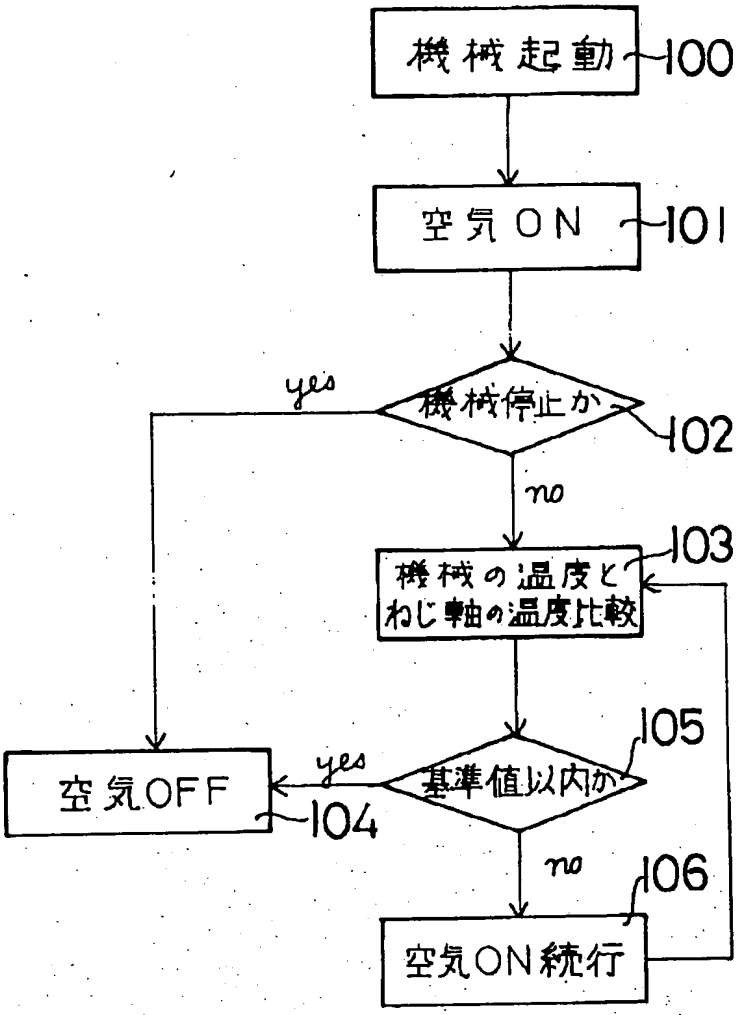
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]

... Page Blank (uspto)